Research, Monitoring & Evaluation
for the 2000 FCRPS Biological Opinion

OUTLINE

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1.0 INTRODUCTION

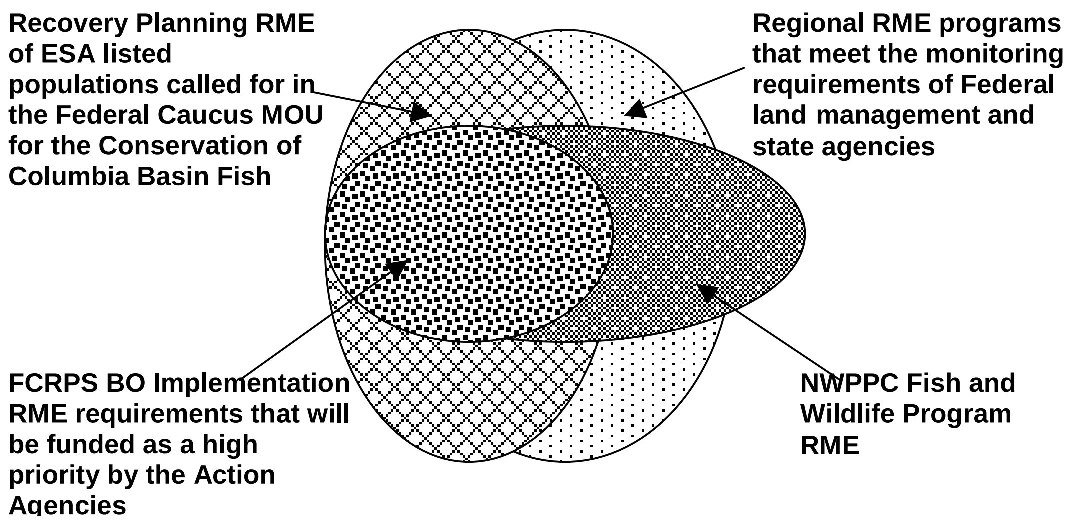
The NMFS and the Federal Columbia River Power System (FCRPS) Action Agencies (Bonneville Power Administration, Corps of Engineers, Bureau of Reclamation) are working together to develop and implement a comprehensive Research, Monitoring, and Evaluation (RME) Program that is called for under the 2000 FCRPS Biological Opinion (BIOP) and the Federal Columbia River Salmon Recovery Strategy (All-H Strategy). This program is intended to provide information needed for assessment of the performance of ESA listed anadromous fish populations at the 5 and 8 year BIOP check-in evaluations, and for the identification and prioritization of actions that are the most biologically effective. Significant elements of the RME program are identified through a number of specific action items called for within the BIOP Reasonable and Prudent Alternative (RPA). This draft document outlines a RME program that satisfies the needs of the FCRPS BIOP. The RME program is a Columbia River Basin ESA focused program that will be integrated with the broader RME needs of the Federal All-H Strategy and the Northwest Power Planning Council's Fish and Wildlife Program and in coordination with other regional Federal and state RME programs. The scope of this program, levels of funding, and resource commitments relative to overlapping requirements of Federal agencies under the All-H Strategy are still under development and resolution.

RME is a critical component of Federal and state legal requirements for anadromous salmonids – both wild and hatchery -- and for tracking efforts to improve aquatic habitat. Currently there is a broad, loose patchwork of RME programs in different phases of planning, development, and implementation that could benefit from increased coordination (see Figure 1). RME programs are called for by the Federal All-H Strategy, the FCRPS BIOP, and the NWPPC Fish and Wildlife Program. There are existing Federal programs that focus on monitoring freshwater habitat and environmental conditions, such as the Forest Services' Northwest Forest Plan and Pacfish/Infish and EPA's EMAP. At the state level, both Washington and Oregon have formulated their own plans for monitoring freshwater habitat conditions. There also are collective efforts such as the Lower Columbia River Estuary Program (LCREP), a joint program involving agencies from Washington and Oregon, federal agencies and local jurisdictions. These monitoring programs overlap one another at various spatial and temporal scales. To the extent possible, it would be advantageous to coordinate with these efforts in the development of a RME program that meets BIOP needs.

As represented in the Figure 1, the FCRPS RME Program overlaps with other regional programs having their own needs and geographic coverage. The NMFS and the AA need to formulate a comprehensive plan that addresses the BIOP requirements for ESA-listed stocks. Where there are opportunities to coordinate with other programs or use their monitoring data the NMFS and Action Agencies plan to do so. NMFS and the Action Agencies are cooperatively developing this FCRPS RME Plan with the intent that it will complement and integrate with other regional activities to the greatest extent practicable. Both the Action Agencies and NMFS recognize that the various programs have different goals, and that this will preclude region-wide reliance on any single monitoring program.

This document is organized into four major sections. The first describes the framework and components of the FCRPS RME Program. The second section describes each of the program components in detail. The third section describes the unique role of Pilot Studies in ground-testing the RME principals prescribed in the plan. The fourth section describes opportunities to interface with and complement other regional monitoring programs.

Figure 1. Regional RME needs - cross coverage:



2.0 FCRPS RME FRAMEWORK & COMPONENTS

The NMFS-Action Agency program is based on the research and monitoring needs identified in the BIOP. Five principal categories are identified: status monitoring, action effectiveness research, critical uncertainty research, implementation (compliance) monitoring, data management , and regional coordination. Here we briefly identify key objectives for each RME category. Except as noted, details will be provided in subsequent sections.

2.2 Components

1. Status Monitoring - The objective of Status Monitoring is to document progress toward the recovery of listed ESUs and their habitat. Status Monitoring assesses the condition or trend of ESUs and key environmental attributes. Condition is compared to performance standards using quantitative tests conducted at check-in periods.

2. Action Effectiveness Research - The objective of Action Effectiveness Research is to establish effects of actions on fish survival, fish condition, and habitat condition in a quantitatively rigorous approach. This information will be critical to the projections of the expected benefits of hydro and off-sight mitigation actions in the out year check-in evaluations. This research requires well-designed experiments, with treatment areas, controls and adequate replication. Casual monitoring will not meet the objectives of this component.

3. Critical Uncertainty Research – the primary objective of Critical Uncertainty Research is to resolve key issues that emerged in the BIOP evaluations of the proposed actions and development of the Reasonable and Prudent Alternative, which will be needed in performance check-in evaluations. These are critical areas of uncertainty in survival conditions and needed survival improvements identified for fish populations of each ESU. Those critical uncertainties include: the reproductive success of hatchery fish spawning in the wild; the magnitude of delayed differential mortality of transported smolts (D); and the extent of extra mortality and its causes. Included under this category of RME are research projects that may not have been designated as "critical" to BIOP assessments, but are called for under a number of RPA actions.

4. Implementation/Compliance Monitoring - The objective of this category of RME actions is to document that management actions have been executed as prescribed. It involves having COTR's track the execution of the management projects, determining if they are in compliance with the specifications in the directive or work statement. In some cases such compliance monitoring may extend beyond the implementation phase. For example, it will be necessary to ensure that riparian fencing remains in place for some extended period beyond the construction phase. (No further details in this draft of the document.)

5. Data Management - The complex of information obtained through this program will need to be compiled and organized in a systematic manner. At this time there is no adequate system in place. The objective of this task will be to establish such an information system. It will involve compiling and archiving monitoring data, derived estimates and all technical reports treating these issues. It may also involve archiving extant information. Whatever system is

adopted will need to ensure timely and easy access to the information. (No further details in this draft of the document.)

6. Regional Coordination and Integration – The research, monitoring and data management requirements of the BIOP will need to be coordinated across the different categories of RME and the various federal and state programs. This coordination will be essential to maximize the amount and quality of RME within limited budgets, and to avoid confounding effects of multiple or overlapping treatment and control sites. (No further details in this draft of the document.)

2.2 Component categories

Some of the NMFS-AA RME program components can be further delineated by category . For example, Status Monitoring is required throughout the CRB, but requires fundamentally different approaches in different geographic areas. Similarly, Action Effectiveness Research can generally be associated with H specific actions or processes. Therefore, we adopt the following structure for organizing, designing and implementing an RME program for the FCRPS BIOP.

1. Status Monitoring
   - Ecosystem/Landscape
   - Tributary Habitat
   - Hydro-corridor
   - Estuary/Ocean

2. Action Action Effectiveness Research
   - Hydro
   - Habitat
   - Hatchery
   - Harvest

3. Critical Uncertainty Research (e.g. D, extra mortality, hatchery spawner reproductive success)

4. Implementation/Compliance Monitoring

5. Data Management

6. Regional Coordination

3.0 RME DETAILS

3.1 Status Monitoring

Status monitoring involves tracking the condition of ESA-listed salmonid populations and their habitat relative to performance standards or other evaluation criteria. The need for status monitoring and corresponding performance standards was identified in the FCRPS BIOP and

specifically called for under RPA Action 180. Information gathered through status monitoring will be used to identify and prioritize areas requiring improvement.
The data will be important in recovery planning for ESA-listed salmonids, and will be useful for NPPC sub-basin planning efforts. Long-term status information collected within an appropriate statistical framework may also be useful in establishing correlations between the condition of fish populations and their habitat.

Two other components of the RME framework – Action Effectiveness Research and Critical Uncertainty Research - are separate from status monitoring activities, but complement and depend on status monitoring for the baseline conditions or context in which the work is done. In some cases, indicators tracked for status monitoring may also have application in action effectiveness and critical uncertainties research, and vice versa. However, the objectives, and therefore the scope and design, of those monitoring components differ from status monitoring in terms of spatial and temporal sampling and the required statistical framework. RME components are therefore treated separately in this report.

Below, we identify the performance measures, or indicators, that must be monitored to satisfy the Action Agencies obligations under the BIOP. We also show where these may have broader application to support planning and adaptive management as identified in the Action Agencies Implementation Plans. We emphasize performance measures necessary to conduct tests and evaluations required at the out-year check-ins and for annual implementation planning. These define the key elements of the Status Monitoring program. In addition to those essential status monitoring indicators, additional performance measures, beyond those explicitly specified in the BIOP, may provide useful information.

The 2000 FCRPS BIOP specified two tiers of Status Monitoring. We have incorporated the features of those tiers into our framework. The BIOP Tier 1 monitoring (Ecosystem/Landscape) activities appear as a specific subcomponent within Status Monitoring. Tier 2 monitoring activities are now treated in the three different geographic zones (tributary, hydro, estuary) designated in our framework.

Status Monitoring
- Ecosystem/Landscape
  - Fish indicators
  - Environmental indicators
- Tributary
  - Fish indicators
  - Environmental indicators
- Hydro-corridor
  - Fish indicators
  - Environmental indicators
- Estuary/Ocean
  - Fish indicators
  - Environmental indicators

3.1.1 Status Monitoring- Ecosystem/Landscape

Ecosystem or landscape scale monitoring is intended to provide a broad overview of anadromous salmonid population distribution and habitat condition across the listed ESUs. The objectives are to:

- Identify the entire geographic range used by anadromous salmonids.
- Detect changes in population distribution.
- Identify key landscape scale habitat attributes.
- Identify associations between salmonid presence and habitat attributes.
- Ground-truth and update habitat databases.

Ecosystem monitoring has the following general features:

1. Temporal scale: compilation of information occurs every 5-10 years.
2. Spatial scale: coverage spans the entire portion of the Columbia Basin occupied by ESA-listed ESUs.
3. Statistical properties: Census approaches rather than systematic sampling is envisioned.

3.1.2 Status Monitoring- Geographic Zones (tributaries, hydrosystem, estuary)

This provides a more detailed view of fish and habitat status on an annual basis, and is conducted in areas of known salmonid distribution. The objectives are to:

- Document changes in the adult and juvenile abundance of populations and ESUs.
- Estimate key life stage survival rates.
- Track changes in key environmental/habitat indicators.

This type of status monitoring has the following features:

1. Temporal scale: Sampling occurs annually or more frequently, depending on the indicator.
2. Spatial scale: The geographic scale of monitoring will be dictated primarily by the population unit(s) designated through the Technical Recovery Teams (TRT's). The Action Agencies and NMFS expect that most efforts will be at the sub-basin level.
3. Statistical properties: Unbiased estimates with specified sampling and measurement error are required.

3.1.3 FCRPS Performance Standards - Status Monitoring

The NMFS BIOP identified a number of performance standards to be examined at out-year check-ins. Status monitoring needs are guided by these quantitative standards and tests. As described thus far, some of the performance standards that are intended to be applied in these check-ins are rather general and may need more detailed development or clarification of their application. Similarly, more specific detail in spatial and temporal requirements of status monitoring will need to be identified to meet the needs of these performance evaluations.. The Action Agencies place a high priority on status monitoring required to meet the performance standards identified in the BIOP. They want to ensure that at a minimum, status monitoring is sufficient to perform these out-year tests to determine whether or not they have met the BIOP performance standards.

Some BIOP performance standards apply to the overall condition or productivity of the population unit (e.g. ESU), others specify life stage survival rates, and still others remain to be specified. In the BIOP, sections 9.2.2 and 9.3.3 identify 4 classes of performance standards:

1. ESU population abundance and status;
2. Hydro-system performance;
3. Offsite Mitigation;
4. Physical performance standards.

To determine if the standards are met, it will be necessary to monitor indicators or performance measures that will be used in the calculations and analyses. Thus, the quantitative characteristics of the performance standards dictate the set of indicators that must be monitored. Figure 9.5-2 in the BIOP (reproduced below as Figure 2) clearly depicts the linkage between the performance standards, evaluations and subsequent decisions. The Action Agencies RME monitoring program is designed to satisfy that evaluation process.

Beyond the performance standards-based Status Monitoring requirements expressed in the BIOP, there are broader regional needs for monitoring. In contrast to the BIOP, these regional interests are not restricted to ESA-listed anadromous salmonids. Unlisted natural stocks, hatchery populations, and resident fish species all require monitoring under other regional programs. Also, a broad assortment of environmental variables will require monitoring in geographic areas that extend beyond the demarcations of the ESUs. This plan does not satisfy those broader regional needs. Instead, it focuses exclusively on the Action Agencies monitoring requirements specified in the FCRPS BIOP.

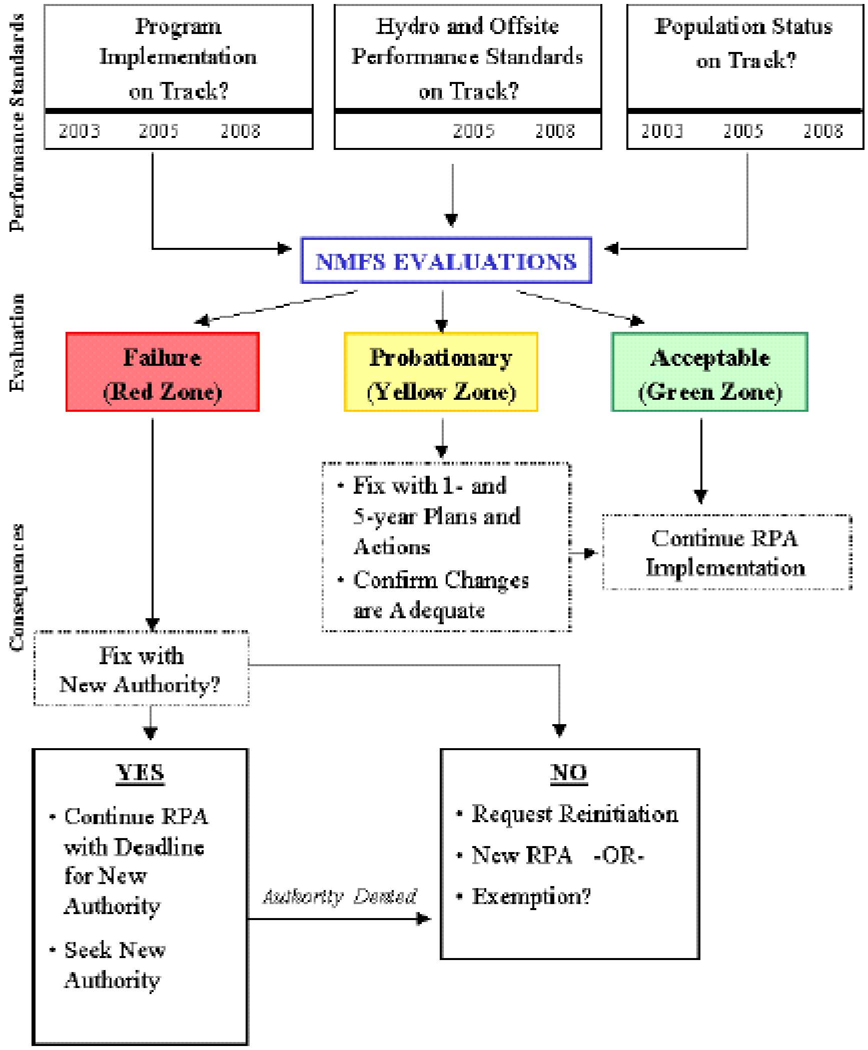


Figure 2. Source: BIOP, Figure 9.5-2.

3.1.3.1 Population Level Performance Standards

In accordance with 2000 FCRPS BIOP, the anadromous salmonid status monitoring program under the Action Agencies Implementation Plan must collect data to answer the following four questions at the 2005 and 2008 check-in evaluations. These questions constitute quantitative tests, and they are specified as requirements for assessing the status of ESA listed salmonid species in the Columbia River Basin (FCRPS BIOP, 9.2.2.1).

1. Is the annual population growth rate greater in 2005 and 2008 than during the base period (1980 – 2000)?

2. Is the annual population growth rate in 2005 and 2008 greater than or equal to the projected growth rate based on improvements from actions taken in the 1995 biological opinion, reductions in harvest that occurred after 2000, and the survival standards in the Mid-Columbia Habitat Conservation Plan?

3. Is the projected annual population growth rate in 2005 and 2008 (based on best available information about the expected effects of hydro and off-sight mitigation actions and other regional actions under the All-H strategy) equal to or greater than the growth rates believed necessary to achieve the 48-year recovery criteria?

4. Is the annual adult return of wild fish as represented by the 5-year geometric mean for each ESU and population greater than the ESU and population size (5-year geometric mean) in 2000?

To address these standards, the Actions Agencies must measure and document the change in population status by monitoring adult abundance. This requires enumerating (census of all adults) or estimating adult abundance on an annual basis. What is unclear at present is the scale (population/subbasin/ESU) and precision (+/- 10%, 20%, 30%) of the monitoring for each listed species. The NMFS-Action Agency RME group will make recommendations for these aspects of the monitoring program design, but can not alone set these standards.

3.1.3.2 Hydro-System Survival Performance Standards

Quantitative performance standards have also been identified for the hydro corridor. Salmonid survival rates through the hydrosystem are of key concern. The BIOP specifies survival standards for both adults and juveniles migrating through the system (BIOP Table 9.2-3, reproduced on next page). ESUs of steelhead, chinook, and sockeye are the populations that must be monitored, per the BIOP.

3.1.3.3 Offsite Mitigation Performance Standards

A generic class of quantitative standards have been prescribed for the collective non-hydro actions of BIOP offsite mitigation actions and actions of other regional entities under the All-H Strategy and other regional mitigation programs. As defined in BIOP Table 9.2-4 (reproduced on next page), this is the estimated percent change in survival throughout the life-cycle that is needed to achieve survival and recovery criteria, after satisfying hydro performance standards. These standards offer little direction in specifying specific indicators for status monitoring.

ESU	Adult Survival Rate		Juvenile Survival Rate		
	FCRPS System	Per FCRPS Project[1]	FCRPS Inriver Only		FCRPS Combined[2] (Transport + Inriver + Differential Mortality of Transported Fish)
			System	Per Project[1]	
Chinook Salmon					
SR spring/summer	85.5	98.1	49.6	91.6	57.6
SR fall	74.0	96.3	14.3	78.4	12.7
UCR spring	92.2	98.1	66.4	90.3	66.4
UWR	N/A	N/A	N/A	N/A	N/A
LCR	98.1	98.1	90.7	90.7	90.7
Steelhead					
SR	80.3	97.3	51.6	92.1	50.8
UCR	89.3	97.3	67.7	90.7	67.7
MCR	89.3	97.3	67.7	90.7	67.7
UWR	N/A	N/A	N/A	N/A	N/A
LCR	97.3	97.3	90.8	90.8	90.8
CR chum salmon	N/A	N/A	N/A	N/A	N/A
SR sockeye salmon	88.7	98.5	N/A	N/A	N/A

Source: Adult standards taken from Table 9.7-2. Juvenile standards taken from Table 9.7-1.
[1] Per-project inriver survival rate calculated as the xth root of the system inriver survival rate (where x = number of FCRPS projects encountered). They are provided for illustrative purposes only. They are *NOT* intended to be interpreted as project-specific standards, or to be used in any way to support curtailment of survival improvement measures at an individual project.
[2] Values represent averages over the water years and D values in Table 9.7-1.

BIOP Table 9.2-3

BIOP **Table 9.2-4.** Estimated percentage change (i.e., additional improvement in life-cycle survival) needed to achieve survival and recovery indicator criteria after implementing the hydro survival improvements in the RPA. (A value of 26, for example, indicates that the egg-to-adult survival rate, or any constituent lifestage survival rate, must be multiplied by a factor of 1.26 to meet the indicator criteria.)

Spawning Aggregation	Needed Survival Change	
	Low	High
Snake River Spring/Summer		
Bear Valley/Elk Creeks	0	0
Imnaha River	26	66
Johnson Creek	0	0
Marsh Creek	0	12
Minam River	0	28
Poverty Flats	0	0
Sulphur Creek	0	5
Snake River Fall Chinook		
Aggregate	0	44
Upper Columbia River Spring		
Wenatchee R.	51	178
Snake River Steelhead		
A-run Aggregate	44	214
B-run Aggregate	92	333
Upper Columbia River Steelhead		
Methow R.	0	110
Mid-Columbia River Steelhead		
Deschutes R Sum	102	226
Warm Springs NFH Sum	36	36
Umatilla R Sum	27	31
Yakima R Sum	0	0
Columbia River Chum Salmon		
Grays R. west fork	0	0
Grays R. mouth to head	18	18
Hardy Creek	0	0
Crazy Johnson Creek	0	0
Hamilton Creek	36	36
Hamilton Springs	0	0

Notes: Low and high estimates are based on a range of assumptions, as described in the text.
The values presented in this table are intended to provide perspective and enable NMFS to make a qualitative judgment regarding the potential to improve the productivity of listed ESUs enough to avoid jeopardy. As discussed in the text accompanying this table, the effects of this uncertainty are particularly significant for SR steelhead and UCR chinook and steelhead.

3.1.3.4 Environmental and Physical Performance Standards-

Except for the Hydro-corridor, The BIOP only generally describes the types of performance standards that may be derived for Habitat and Hatchery areas. For the Hydro-corridor the standards take the form of flow targets and spill and transportation schedules, intended to maximize smolt survival. The BIOP leaves the door open for the community to specify more tangible performance standards. It terms of developing specific sets of habitat and environmental indicators for the three geographic zones, the BIOP offers little guidance. This is another area the Action Agencies/NMFS RME team has been attempting to solidify.

3.1.4 Indicators (Performance Measures)

Using the BIOP Performance Standards as a foundation, the RME Team has designated the following classes of performance measures, or indicators, as the foundation of the Status Monitoring. An "**E**" indicates an essential need to acquire the information. These are essential for meeting the Action Agencies obligations to track progress toward recovery. An "**s**" indicates useful, but supplemental information not explicitly required in order to meet BIOP-specified performance standards. A "**?**" indicates that the information is desirable, but the means to obtain representative and useful estimates is unclear. For example, in tributaries juvenile salmonids can disperse or migrate during different times of the year at various life stages. How, when, and where to monitor a life stage(s) to represent population productivity may be difficult to determine. As another example, it is not clear how to estimate juvenile and adult survival in the estuary/nearshore zone. At this juncture, this table represents an initial prioritization roadmap for FCRPS BIOP status monitoring.

Status Monitoring - classes of indicators/performance measures

Monitoring Zones	**Abundance**		**Survival**		**Environmental conditions**
	Juveniles	**Adults**	**Juveniles**	**Adults**	
Tributaries	s?E	**E**			sE
Hydrosystem	s	**E**	**E**	**E**	**E**
Estuary			?	?	s

3.1.4.1 Population-Based Indicators

To determine changes in population growth rate and abundance, spawner escapement and removals must to be estimated. Removals may be caused by passage mortality or in-river harvest. Different species offer different opportunities for estimating spawner escapement. For example, redds counts have generally been adopted as acceptable for tributary spawning chinook. In contrast, steelhead redds can be difficult to observe during spawning periods when flows are high, thus other enumeration techniques may be required. For mainstem spawning species like fall chinook, deep water redds are difficult to identify, so dam counts must usually suffice.

Defining the goals of the proposed monitoring effort is a fundamental first step. To initially define performance measures, the RME team has used the data requirements of the analytical process that uses the monitoring data. For example, the life cycle analyses employed in the BIOP requires annual estimates of age composition and sex ratio for the returning adults. In compiling this list of candidate performance measures we did not restrict data needs to BIOP driven analyses, but attempt to satisfy broader applications as well. Furthermore, the RME Team recognized those future models for population viability and other BIOP applications may change, requiring additional data (e.g., annual age structure).

Candidate fish population indicators/performance measures are:

Adult Life Stage-
1. Adult counts: weir or dam counts.
2. Spawners: carcass or redd counts.
3. Removals by fisheries or passage mortality
4. Hatchery fraction of natural spawning fish: hatchery marks.
5. Sex ratio of spawners or adults: carcass surveys or traps.
6. Age structure: scale or length analysis.

Juvenile Life Stage-
1. Smolt abundance estimates at strategic locations

The enumeration or estimation of spawner abundance is required to conduct the BIOP-specified performance standard tests. Estimates of juvenile abundance are not explicitly required under the BIOP, but are necessary to generate estimates of survival, SARs, and as population status indices. Opportunities to obtain useful juvenile indicators will vary by ESU. For example, Snake River fall chinook are particularly problematic. They migrate throughout the year in the mainstem, including periods when sampling devices are inactive. However, whenever possible, juvenile abundance should be estimated for populations/ESUs.

3.1.4.2 Life Stage Survival as Indicators

Hydrosystem- To determine if the Hydro performance standards are being met it will be necessary to estimate the survival of adults and juvenile salmonids as they migrate through the FCRPS. The RME Hydro Team has not yet specified tools and protocols for accomplishing this. However, indicators will include estimates of:

1. Adult hydro passage survival (project and system level)
2. Juvenile hydro passage survival (project and system level)

Estimates of adult and juvenile survival within the hydrosystem corridor are called for under the BIOP. Specific performance standards (survival targets) are prescribed therein (BIOP Table 9.2-3, reproduced above).

Estuary- No performance standards for survival are specified in the BIOP for the estuary. However, life stage specific survival estimates (adult and juvenile) were identified as useful performance measures for use in future modeling analyses. As yet technical approaches for obtaining such estimates have not been developed.

<u>3.1.4.3 Environmental and Physical Indicators</u>

Hydrosystem- In the BIOP, environmental/physical performance standards have only been developed for the hydro-corridor. Currently there are monitoring procedures in place to track key indicators associated with those standards. These data are collected by the USACE, and regularly reported by the FPC and independent data systems like DART. The essential indicators include:

1. Total flow (kcfs) at index dams (LGR and MCN)
2. Spill at each dam in the FCRPS
3. Total dissolved gas concentrations in forebays and tailraces of all dams.

Other environmental factors are also monitored by the USACE, but are not specifically linked to any quantitative standards expressed in the BIOP. These include:

1. Turbidity and
2. Water temperature.

The Action Agencies view these as important indicators nonetheless, and see a continued need to database this information as part of the status monitoring program for the hydrosystem.

Estuary- (place holder)

Tributaries- (place holder)

3.1.5 Other Status Monitoring Needs And Programs

Collectively the indicators identified herein are the key elements comprising the Status Monitoring component of Action Agencies FCRPS RME Program. However, there are other regional monitoring programs that need the same data, and additional information beyond the scope of the Action Agencies Plan. Those other regional monitoring programs were briefly discussed in Section 1.0 of this document.

The need for, and benefits of, a systematic, integrated, regional status monitoring program is recognized by a broad spectrum of federal, state, and tribal fish and wildlife recovery and restoration plans (NMFS 2000a, NMFS 2000b, CRITFC 1995, Roger *et al. 2000*). Despite this common goal, actual implementation of a cohesive status monitoring program has proven to be elusive. Obstacles are evident in the form of policy, technical, and on-the-ground challenges including:

1. Policy Challenges
   - Unspecified level of uncertainty that is acceptable for decision making
   - Cooperation of necessary private, local, state, tribal, and federal jurisdictions is difficult to achieve
   - Agencies have different scopes of responsibility and authority

- Agencies often have no mandate for supporting regional programs
- Different entities and programs operate at different spatial and temporal scales
- Perceived high cost
- Insufficient technical feedback to policy makers

2. Technical Challenges
   - No comprehensive catalog of existing monitoring efforts
   - No concise, clearly described basin-wide monitoring program presently exists
   - Specific monitoring responsibilities need to be assigned to, and accepted by a complex of agencies
   - Data management technology is evolving rapidly and the various entities are at different stages of ability and have different levels of available resources.

3. On-the-Ground Challenges
   - Coordinating field crews from multiple agencies is operationally difficult
   - Field crews often do not have time for data entry and QA/QC activities
   - A agreed upon manual describing field data collection methods is needed to guide diverse field crews

There is much work to be done in this regard, which will involve the participation of many agencies besides the Action Agencies and NMFS. A common vision and full participation by all affected agencies is required. NMFS and the Action Agencies cannot develop a regional plan on their own, nor would it be appropriate. But they can focus on particular issues in the context of the FCRPS BIOP. One concern is that a standard set of guidelines or procedures for collecting monitoring information has not yet been established. This is necessary to ensure that compatible data are collected by different agencies, and the quality of that data is sufficient to satisfy the check-in tests envisioned by NMFS. In this regard the NMFS-Action Agency RME team can propose guidelines that appear satisfactory, but they can not demand these guidelines be applied except for projects that they fund.

Herein NMFS and the Action Agencies propose preliminary guidelines for establishing sound protocols for collecting status monitoring data. The focus here is on biological indicators linked directly to listed salmonid ESUs. With respect to environmental indicators, NMFS and the Action Agencies rely on established environmental monitoring programs to develop appropriate methods for application in the tributary and estuary zones, as well as at the ecosystem/landscape level

3.1.6 Guidelines for implementing status monitoring- FCRPS BIOP Focus

The following sections briefly outline the proposed guidelines for implement a status monitoring program targeting salmonid ESUs listed under the ESA. They may also have broader application for resident fish populations and their habitats. The Action Agencies and NMFS suggest that if the guidelines are implemented the status monitoring program will likely meet the needs of the BIOP and may satisfy broader regional goals. By specifying these guidelines the Action Agencies do not imply that they alone are responsible for acquiring, or entirely funding the acquisition of these data. Cost-sharing among agencies is anticipated.

3.1.6.1 Ecosystem Level Status Monitoring

Much of the critical data for assessing ecosystem status should be collected at a watershed to sub-basin scale. There are two classes of landscape-level ecosystem attributes: salmonid species presence/absence and environmental/habitat conditions. Both fish and environmental data should be compiled and reported every 5-10 years, although sampling may occur in more frequent time-steps.

Tasks will include:

1. The acquisition and digitizing of aerial or satellite imagery of the entire Columbia River Basin, for key landscape attributes.
2. Survey the presence/absence of adult anadromous salmonids to document range expansion or contraction.

Landscape-level data collection will allow a more detailed assessment of land use and land cover variables than is currently available. This assessment, in turn, will allow the association of potentially important watershed-level characteristics with salmon population status. In addition, repeated collection and assessment of the variables through time will allow analysts to assess if changes in environmental characteristics are associated with changes in salmonid population status. These data will have value for resource and wildlife management well beyond listed salmon species.

Proposed Guidelines:

1. Clearly identify the appropriate geographic scales (e.g. sub-basin, watershed) and resolution (e.g., 1:24k, 4m pixels) at which the status indicators are measured.
2. Identify the indicators that will be directly measured (e.g. fish presence/absence, DEM) to estimate ecosystem status.
3. Describe the method used for determining derived indicators (land classification, stream network).
4. Provide an assessment of the accuracy and precision associated with the proposed methods for estimating indicator values.

The Action Agencies and NMFS rely on federal land use agencies and state agencies to identify a set of key environmental/habitat indicators that should be monitored, although we offer some suggestions including geology/soils, land classification, stream network, DEM, roads, passage barriers, and land ownership. The Pacific Northwest Ecosystem Research Consortium has described sampling methods and associated precision estimates for these indicators. This may provide a model for a broader regional program.

3.1.6.2 Population Level Status Monitoring-Adults:

In order to track the status of a population, spawner escapement and removals en route to the spawning ground must to be estimated. Removals may be caused by passage mortality or in-river harvest. Different species offer different opportunities for estimating spawner escapement. In the Columbia River Basin, redds counts have generally been adopted as acceptable for tributary spawning chinook. In contrast, steelhead redds are difficult to observe during spawning periods when flows are high, and are not particularly useful for estimating escapement using traditional peak count methods. However, new methods recently developed by the Oregon Department of Fish and Wildlife Corvallis Research Lab indicate that cumulative steelhead redd counts may be a very reliable method for estimating adult steelhead abundance (Jacobs et al. 2001). For mainstem spawning species like fall chinook, counting redds in large, deep rivers is not very reliable, so dam counts usually must suffice. Recent work by the USFS Rocky Mountain Research Lab has begun to address the measurement error associated with a variety of types of redd count methods (Dunham et al. 2001, Thurow 2000).

Proposed Guidelines -Adult Life Stage:

1. Clearly identify the demographic scale (e.g. population, ESU, deme; wild/natural or hatchery origin) for which abundance estimates will be produced.
2. Demonstrate that the target unit is readily distinguishable from other sympatric population units (e.g. spawning location, timing, etc.).
3. Identify the performance measure or indicator that will be monitored/enumerated (e.g. redds, carcasses, weir counts, dam counts etc.) in order to estimate spawner escapement. If multiple methods (e.g., weir counts and redd counts) are used to enumerate the same population, specify.
4. Describe the method used to enumerate the indices, e.g., aerial or ground surveys, peak or cumulative (repeated) counts, and the error associated with the method.
5. Specify any expansion factors (e.g. spawners/redd, expansions beyond index areas) or other adjustments (e.g. harvest removals, passage mortality) that need to be applied to the raw counts. Provide the rationale supporting the use of those expansion factors, how the factors change over time, how they are estimated, and assess their reliability.
6. Provide estimates of the annual age structure of the sampled population, and how this is estimated.
7. Provide an assessment of the accuracy and precision associated with the proposed methods for estimating spawner escapement, or total numbers of returning adults.

Here we propose precision targets (Coefficient of Variation: CV = 100 x standard deviation/mean) associated with key indicators to be CV < 15%, unless noted otherwise. All data needs to identify precision. It is assumed that estimates are unbiased, and monitoring groups can verify this empirically. Data will be collected on an annual basis at the sub-basin scale:

- Adults, Spawners, or Redds
- Age structure of spawning population
- Sex ratio of spawning population
- Fraction of naturally spawning fish that are of hatchery origin, CV < 10%.

Recent work by ODFW 2001 and Jacobs and Nickelson (1998) suggest protocols and sampling methods that may provide satisfactory precision for the above indicators.

3.1.6.3 Population Level Status Monitoring-Juveniles

The abundance of juvenile salmonids in tributary habitats can be a useful indicator of population productivity. Some measure of juvenile production for each listed ESU would be advantageous, however information in selective sub-basins may have to suffice. The juvenile component of the status monitoring program seeks to generate at a minimum a trend in the juvenile production index at the sub-basin scale, but when possible should generate the status of the juvenile population by demographic unit. In most cases, population size estimates will be based on sampling by trap, snorkeling, or mark recapture. Often such estimates are so coarse they are characterized as general indices. Depending on the life stage of interest (fry, parr, smolt) sampling opportunities vary.

Proposed Guidelines -Juvenile Life Stage:

1. Clearly identify the demographic unit (e.g., population, ESU, deme; wild/natural or hatchery origin) over which sampling will take place.
2. Clearly identify the spatial scale represented by each samples (e.g., reach, watershed, basin).
3. Identify the performance measure or indicator that will be monitored (e.g. summer/winter juveniles, outmigrating smolts). If different methods are used to enumerate the same population, specify.
4. Describe the method used for enumerating the indices, e.g., snorkel surveys, electro-fishing, smolt trap, and the error associated with the method.
5. Specify any expansion factors (e.g. aerial expansions, trap efficiency) or other adjustments (e.g., daylight trapping only) that need to be applied to the raw counts. Provide the rationale supporting the use of those expansion factors, how the factors change over time, how they are estimated, and assess their reliability.
6. Provide an assessment of the accuracy and precision associated with the proposed methods for estimating juvenile abundance or an index of juvenile abundance.

Here we propose precision targets (CV < 15%) associated with key indicators. It is assumed that estimates are unbiased. Data will be collected on an annual basis at the sub-basin scale:

- Estimate abundance of instream juveniles
- Estimate out-migrating juveniles
- Age/size classes of sampled juveniles
- Condition of sampled juveniles

A recent work by Rodgers (2001) and previous papers by Hankin and Reeves (1984, 1988) suggest protocols for sampling methods that provide satisfactory precision for the above indicators.

3.1.6.4 Environmental/Habitat Status Monitoring- Geographic Zones

The goal of habitat or environmental status monitoring is to quantify and characterize the condition of habitat occupied by listed anadromous salmonids at more localized and appropriate geographic scales. Information derived from these analyses may be useful to describe the current environmental conditions that support native salmonids and to develop associations with populations trends. The responsibility for monitoring environmental conditions in the hydro-corridor is clearly the responsibility of the Action Agencies. The responsibility for environmental/habitat monitoring in the tributary and estuarine zone will be jointly shared with established programs like EMAP, PACFISH/INFISH, the OR Plan, WA Plan (SSHIAP), and the Lower Columbia River Estuary Plan. Guidelines proposed here are generic and may be appropriate for all applications.

Proposed Guidelines- Environmental/Habitat Status Monitoring

1. Clearly identify the appropriate geographic scales (e.g. province, ecoregion, subbasin, etc.) for sampling.
2. Identify the indicators that will be monitored (e.g. land cover, habitat types, stream temperature, summer base flow, etc.).
3. Describe the protocol for measuring or estimating each indicator.
4. Provide an assessment of the accuracy and precision associated with the proposed methods for estimating indicator values.
5. Describe the known or probable relationships between environmental attributes and salmonid productivity.
6. What is the status of environmental attributes potentially affecting salmonid populations?
7. How do these attributes change through time?
8. Assess the associations between environmental attributes and salmonid population status.

Here we identify candidate indicators and suggested precision (CV) targets for indicators/attributes at the sub-basin scale for annual estimates. Estimates should be unbiased.

Biological Condition (CV < 15%)

- Macroinvertebrate assemblage
- Fish and amphibian assemblage

Chemical Water Quality (CV < 15%)

- Dissolved oxygen,
- pH
- Conductivity
- Nutrients (N and P)
- Solids
- Pesticide and heavy metal contamination
- Stream temperature

Physical Habitat (CV < 25%)

- Channel Form
- Valley Form
- Valley Width
- Geomorphic channel
- Channel Substrate
- Canopy cover
- Large woody debris
- Riparian vegetation

- Land use
- Number of diversions or dams
- Qualitative or quantitative assessment of erosion processes
- Channel modification
- Instream flow

References describing protocols for sampling methods that provide the desired precision include:
Kaufmann P.R. et al. 1999, Thom, B.A. et al. 1999.
ODFW Habitat sampling protocol manuals: Jones & Moore 1999, Moore et al. 1998.
ODEQ Habitat sampling protocol manuals/reports: Oregon Plan 1999, Hubler 2000, Drake 1999, Canale 1998.

3.1.7 Statistically based sampling design for status monitoring

For the system-wide status monitoring program to be both accurate and cost effective, data must be gathered using a rigorous, unbiased sampling design. Sampling designs for spatially explicit data such as habitat surveys are quite complex. The sampling scheme must provide information on the status and trends in abundance, geographic distribution, and productivity of listed anadromous salmonid populations and their habitat at the population to sub-basin scale. The sampling design must estimate these quantities with no bias and known precision. The primary concern is selecting sites across a large spatial area without inflating the variance or biasing the estimate. The traditional sampling approach, simple random samples, has the potential to inflate variance and bias the estimators because the samples can end up clumped in space. The next generation of sampling schemes, stratified random sampling, addresses the spatial distribution of sites if the strata are themselves evenly distributed, but has the potential to introduce hidden biases if the strata are not correctly chosen. In addition, stratification always requires more samples to maintain power across strata. For landscape-scale sampling the ideal system has built-in spatial distribution -- sampling on a grid rather than randomly across space.

For grid-based sampling, the question becomes one of grid shape and site selection. Randomly selected points on the grid will generate the least biased estimators, but can suffer the same problem as simple random samples if the grid units are too small relative to the area of interest. There are many grid-based site selection techniques that provide probabilistic samples that generate unbiased estimates of status and trend. The US Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP) is an example of a spatially balanced environmental monitoring site selection process especially designed for aquatic systems. The state of Oregon has successfully implemented an EMAP based sampling program for coastal coho salmon (Moore 2002). The monitoring program as implemented in Oregon is spatially explicit, unbiased, and has reasonably high power for detecting trends. The sample design is sufficiently flexible to use on the scale of multiple large river basins and can be used to estimate the numbers of adult salmon returning each year, the distribution and rearing density of juvenile salmon, productivity and relative condition of stream biota, and freshwater habitat conditions. In addition, the EMAP site selection approach supports sampling at varying spatial extents. All grids are interpenetrating so that a lower density grid is a subset of all higher density grids.

3.2 Action Effectiveness Research (identify RPAs)

3.2.1 Habitat Effectiveness Research

The Action Agencies (Bonneville Power Administration, United States Army Corps of Engineers, and the Bureau of Reclamation) and the National Marine Fisheries Service (NMFS) have developed proposed guidelines for sponsors and reviewers of action effectiveness research projects (see the document "Guidelines for Action Effectiveness Research Proposals for FCRPS Offsite Mitigation Habitat Measures," by C. Paulsen, S. Katz , T. Hillman, A. Giorgi, C. Jordan, M. Newsom, and J. Geiselman posted at http://www.efw.bpa.gov/cgi-bin/FW/welcome.cgi?ViewMode=ExternalView). These projects are directed at specific categories of offsite (tributary) mitigation measures identified in the NMFS 2000 Federal Columbia River Power System Biological Opinion (BiOp).

The BiOp Research, Monitoring and Evaluation (RME) program has several tasks as defined by RME Reasonable and Prudent Alternative (RPA) Action Items. Among them is the prescription to develop a multi-component monitoring program to assess the effects of actions called for in the BiOp. A specific mandate for the monitoring program—both for status and effectiveness components of monitoring--is provided in section 9.4.2.8 of the BiOp:

Action 9: The Action Agencies, with assistance from NMFS and USFWS, shall annually develop 1- and 5- year plans for research, monitoring, and evaluation to further develop and to determine the effectiveness of the suite of actions in this RPA.

The BiOp also sets a timetable for the development of a monitoring program, and defines the scope for effectiveness monitoring.

> Research, monitoring, and evaluation will provide data for resolving a wide range of uncertainties, including … establishing causal relationships between habitat (or other) attributes and population response, and assessing the effectiveness of management actions. Progress on resolving these uncertainties will be a primary consideration in the 1- and 5-year planning process as well as in the 5- and 8-year check-ins. (BiOp page 9-31)

Within this mandate, research on tributary mitigation actions intended to improve salmon survival rates through is specifically identified in RPA 183:

Action 183: Initiate at least three tier 3 studies (each necessarily comprising several sites) within each ESU (a single action may affect more than one ESU). In addition, at least two studies focusing on each major management action must take place within the Columbia River basin. The Action Agencies shall work with NMFS and the Technical Recovery Teams to identify key studies in the 1-year plan. Those studies will be implemented no later than 2003.

In addition, section 9.6.5.3.3 of the BiOp states that

> Each major habitat or hatchery management action should be assessed immediately to obtain enough information for a complete evaluation at the 5- and 8-year check-in points. (FCRPS BiOp page 9-170)

This Effectiveness Research Guidance is designed to assist researchers, habitat managers, and proposal reviewers in developing effectiveness research programs that will satisfy RPA's 9 and 183.

By placing effectiveness monitoring within the context of BiOp RME and explicitly identifying effectiveness monitoring as research, the BiOp implicitly recognizes that tributary habitat actions constitute ecological experiments. Effectiveness research is, therefore, subject to the standards of scientific research. Specifically, data will be collected within an experimental design, results will be evaluated with respect to control or reference data, variability will be described, in the data is recognized and decision making will be is based on established rules of scientific inference and statistical confidence.

Table 3.1 identifies the potential distribution of habitat-oriented effectiveness studies, by province, affected ESUs, and project category to satisfy monitoring requests outlined in RPA action 183. Project categories are:

1) Screen Irrigation Diversions
2) Barrier Removal
3) Sediment Reduction
4) Water Quality Improvement
5) Nutrient Enhancement
6) Restoration of Instream Flows
7) Restoration of Riparian Function
8) Stream Complexity Restoration

The primary purpose of action effectiveness studies called for under RPA Action 183 is to evaluate of tributary habitat actions for in the 5-year and 8-year check-ins. This information will also help guide planning efforts by identifying the relative effectiveness of different categories of actions. The primary study response needed to meet the check-in assessment of the BiOp is the change in fish survival at one or more life stages associated with the category of action. The off-site mitigation actions are expected to affect both physical or environmental indicators and salmonid survival or condition at any of several life stages. Because habitat actions may require time beyond the BiOp planning horizons to manifest fish survival effects, we also need to establish cause-and-effect relationships between tributary actions and physical/environmental effects that may be detectable sooner than survival changes. This information will be integrated with status monitoring, other types of action effectiveness research, and critical uncertainties research as part of a broader comprehensive Research, Monitoring and Evaluation (RME) Program(s) that is called for by the BiOp, the Federal Caucus Basinwide Strategy, and the Columbia River Basin Fish and Wildlife Program, and outlined in the Action Agencies Implementation Plans.

For more detailed information on habitat action effectiveness research please see the document "Guidelines for Action Effectiveness Research Proposals for FCRPS Offsite Mitigation Habitat

Measures," by C. Paulsen, S. Katz , T. Hillman, A. Giorgi, C. Jordan, M. Newsom, and J. Geiselman (posted at http://www.efw.bpa.gov/cgi-bin/FW/welcome.cgi?ViewMode=ExternalView).

Table 3.1. Distribution of habitat-oriented effectiveness research studies, by province, affected ESUs, project category and examples, to satisfy monitoring requests outlined in Action 183 of the 2000 FCRPS Biological Opinion. Snake River fall chinook and sockeye are not included in this table, because of the minimal affect of tributary habitat improvements anticipated for the ESUs.

Province(s)	Project Category	Examples of projects	ESUs affected
Lower Columbia & Columbia Estuary	Restore riparian function	Reduce land-use activities in riparian areas	Chum LC Steelhead UW Chinook UW Steelhead
	Blockage removal	Improve passage at culverts and diversions	Chum LC Chinook LC Steelhead UW Chinook UW Steelhead
	Sediment reduction	Reduce land-use activities in riparian areas	Chum LC Chinook LC Steelhead
	Improve water quality	Reduce sources of pollution	UW Chinook UW Steelhead
Columbia Plateau and Columbia Gorge	Irrigation screens	Add fish exclusion screens	MC Steelhead
	Restore riparian function	Reduce land-use activities in riparian areas	MC Steelhead
	Blockage removal	Improve passage at culverts and diversions	MC Steelhead
	Sediment reduction	Reduce land-use activities in riparian areas	MC Steelhead
	Improve water quality	Reduce sources of pollution	MC Steelhead
	Nutrient enrichment	Add fertilizer or carcasses to streams	MC Steelhead
Columbia Cascade	Restore instream flows	Acquisition of water rights	UC Spring Chinook UC Steelhead
	Restore riparian function	Reduce land-use activities in riparian areas	UC Spring Chinook UC Steelhead
	Blockage removal	Improve passage at culverts and diversions	UC Spring Chinook UC Steelhead
	Irrigation screens	Add fish exclusion screens	UC Spring Chinook UC Steelhead
Mountain Snake and Blue Mountain	Irrigation screens	Add fish exclusion screens	SRSS Chinook SR Steelhead
	Sediment reduction	Reduce land-use activities in riparian areas	SRSS Chinook SR Steelhead
	Restore instream flows	Acquisition of water rights	SRSS Chinook SR Steelhead
	Blockage removal	Improve passage at culverts and diversions	SRSS Chinook SR Steelhead
	Nutrient enrichment	Add fertilizer or carcasses to streams	SRSS Chinook SR Steelhead

3.2.2 Hydrosystem Action Effectiveness Research

The BIOP calls for action effectiveness research at many mainstem projects to detect local, short term effects of alterations in turbines, bypass systems, spillway operation, and adult passage systems. On the other hand, while the BIOP calls for substantial status monitoring of adult and juvenile survival rates, there is no mandate to conduct effectiveness research regarding flow augmentation or the composite spill program . This is a topic the NMFS/Action Agency RM&E group may wish to discuss.

3.3 Critical Uncertainty Research

3.3.1 "D" Value

3.3.2 Reproductive Success of Hatchery Spawners

Research proposals have been solicited through the Columbia Basin Fish and Wildlife Program for qualified individuals or groups to determine the relative reproductive success of wild and hatchery spawners in one or more populations throughout the Columbia Basin. Such studies must fulfill the requirements outlined in Action Item 182 of the FCRPS Biological Opinion (2000), and if possible, be structured to address issues outlined in Action Item 184.

Statement of Problem: Anadromous salmonids in the Columbia River Basin are artificially propagated at an extremely large scale, both to augment harvest and for conservation purposes. One result of these programs (intentional in some cases and inadvertent in others) is that many populations in the Basin include naturally-spawning hatchery fish. However, in those cases that have been studied in detail, hatchery-origin spawners generally have lower reproductive success when they spawn in the wild than wild-origin spawners. Without knowing the degree of difference in reproductive success between the two groups, the population growth rate or trend of wild populations is difficult or impossible to determine. Determining the relative reproductive success of wild and hatchery spawners is thus a critical component of population status assessment and recovery planning. In addition, a well-designed study to determine relative reproductive success can also address additional issues surrounding artificial propagation programs, including the potential for negative genetic effects on wild populations of artificial propagation.

Proposals will outline a method to estimate the reproductive success of both hatchery and wild fish spawning naturally in the same population. Parentage analysis using molecular genetic techniques is likely to be the most robust method to address this issue; however, other methods will be considered if they address the questions of interest in a sufficiently thorough manner. Studies must be designed to address the following questions:

- Is there differential reproductive success over the entire life-cycle between wild and hatchery-origin fish spawning in the wild?
- If so, what is the magnitude of that difference?

When possible, these studies may also address additional issues of concern for salmon recovery in the Columbia River Basin. The following questions are of particular concern:

- Does interbreeding between hatchery-origin and wild spawners affect the fitness of wild populations?
- Do hatcheries with different rearing techniques (e.g. conservation and mitigation hatcheries) produce naturally-spawning fish with different reproductive success?
- Does continual gene flow from wild to captive populations limit "domestication" in hatchery populations? What is the effect of such continual gene flow on natural populations?
- Can any difference between hatchery and wild spawners or hatchery spawners reared under different regimes be attributed to differential mortality at particular life stages (e.g. egg-fry, fry-smolt, smolt-adult)?

3.3.3 Extra Mortality

Research proposals have been solicited through the Columbia Basin Fish and Wildlife Program for the development and testing of hypotheses regarding causes of extra mortality (EM) and implications for management actions for ESA-listed Columbia River salmonids.

3.3.3.1 Background

Time-series of adult returns for salmon and steelhead indicate that stocks declined throughout the Pacific Northwest starting in the late 1970s (NRC 1996). However, spring chinook and steelhead stocks from the Snake River and Upper Columbia abundance declined more than lower Columbia River stocks. Mortality may be caused primarily by natural processes - predation, competition, effects of ocean productivity, or climate-induced effects on habitat quality. However, mortality may also be related to a variety of anthropogenic factors such as introduced hatchery stocks, degradation of rearing habitat (including the estuary and nearshore ocean), and delayed effects of passage through the hydrosystem.

Models of the effects of the hydrosystem on salmonid populations strongly suggest that direct losses through the hydrosystem cannot account for the changes in spawner/recruit ratios observed between the 1960’s and 1990’s: the stocks declined at much greater rates than would be indicated by acute mortality in the hydrosystem and “D” values (NMFS 2000). Extra mortality, or EM is mortality not accounted for (or perhaps incorrectly accounted for) by:

1) Spawner-recruitment productivity parameters (e.g., Ricker “a” and “b” values);
2) Estimates of direct mortality of inriver juvenile migrants;
3) Estimates of additional delayed mortality of transported fish relative to inriver fish (D value).

Construction of run-of-river dams in the lower Snake and Mid-Columbia is correlated (and hence confounded) with changes in ocean conditions, increased storage capacity in the upper Columbia and Snake river basins, increased hatchery output, decreases in spawning escapement, and many other factors. Since these trends roughly coincide, statistical methods have not been successful in disentangling the cause(s) of extra mortality.

Although past work developed estimates of EM and hypotheses regarding its cause(s) only for Snake River chinook, the NMFS 2000 FCRPS BIOP assumed that EM may be important for all ESU's above McNary Dam (Snake spring/summer chinook, Snake steelhead, Upper Columbia spring chinook, and Upper Columbia steelhead).

Population viability analyses for upriver stocks are very sensitive to what is assumed about the existence and cause(s) of EM: if it is caused by the hydrosystem, upriver stocks can recover only if mainstem dams are removed. PATH (1997 annual report, WOE report, 2000 Experimental management report) produced several hypotheses that might explain EM. Among many possible causes of EM, the PATH hypotheses include the following (PATH shorthand notation in parentheses):

1) The Lower Snake dams (hydro hypothesis). If true, EM should continue so long as the dams are in place
2) Disease or other permanent factors, and will never go away (here-to-stay hypothesis).
3) Long-term changes in ocean climate, and should go away (periodically) as ocean conditions change (climate hypothesis).
4) Lack of carcass-derived nutrients. If true, it could be reduced or eliminated via nutrient additions to freshwater rearing areas (carcass hypothesis).

Many other phenomena may be involved as causal agents, in isolation or combination.

<u>3.3.3.2 Request For Proposals</u>

The Action Agencies (Bonneville Power Administration, US Army Corps of Engineers, and the Bureau of Reclamation) are seeking qualified individuals or groups to design and implement a research program to resolve the causes(s) of EM. Testing of the hydro hypothesis is of particular interest, in light of its relevance to future decisions on dam removal. However, based on the confounding noted above, it is anticipated that other hypotheses will also be formulated, tested, and compared to one another. Ideally, the final product of the research program will be able to make statistically valid comparisons of the relative importance of different cause(s) of extra mortality for each potentially affected ESU.

3.4 Implementation/Compliance Monitoring

3.5 Data Management

The best prospects for scientifically based natural resource management and listed species recovery depend strongly on information systems. In particular, monitoring and evaluation data is of critical importance. Currently the region's information management system is an ad-hoc distributed information system that lacks essential components, and more importantly, coherent organization, standards, protocols, shared responsibility or structure. Because natural resource management is so highly dependent on information, and there is currently no overall 'regional information system umbrella' it is recommended that regional information system development be initiated as soon as possible.

The problem needs to be managed within a formal information system development at an enterprise level, as described, for example in the Federal Enterprise Architecture Framework. A formal approach would systematically develop awareness of the problem, build consensus on the approach, assess the extent and details, undertake renovation and rebuilding of existing information infrastructure, test the solutions and deploy the preferred solutions.

While this structured approach would produce its own recommendations it is likely that a viable solution will involve the development of a Distributed Database Management System (DDBMS). A DDBMS provides the tools and protocols to connect multiple users and databases into a coherent information system. It provides considerable advances over the informal resources currently available through the Internet or Intranets. Users would have the benefit of using common protocols for: information sharing, data inventory, data transfer and interchange, metadata, data recovery, data collection, data distribution, confidentiality, and version control. It is these, and potentially other common elements that distinguish a DDBMS from the current ad-hoc use of the Internet. A critical element is the concept of transparency, that users, to the maximum extent possible should be able to use the new system without needing expert knowledge in computer networking and data transformation. Data-warehouse approaches may also be beneficial for at least part the regional information needs and should be evaluated.

Therefore, the programmatic recommendations for monitoring and the development of an evaluation data management system are the following. Develop the system within an overall information system architecture - a critical and currently missing part of the region's information system. Where possible use of the many potential data centers already exist. Facilitate information portals communicating via the World Wide Web and Internet. Information would be geo-spatially referenced for use in geographic information and database management systems and document.

3.5.1 Information system development - objectives

Develop a system for the efficient and effective collection, management and distribution of information relating to fish and related wildlife restoration and management in the Columbia River Basin. The system must meet information needs in relation to the Endangered Species Act, Northwest Power Act, Treaty trust responsibilities and other relevant requirements. This system should meet the following objectives:

- Meet monitoring and evaluation and scientific research needs and satisfy identified management, environmental and biological objectives of recovery and management efforts;
- Ensure access to biological data relating to fish and wildlife populations in the Columbia Basin, attributes of aquatic, terrestrial and marine habitats, and ecological functions and attributes of species and habitats;
- Include data pedigree and metadata and clearly distinguish primary data and derived information;
- Develop and use common protocols and techniques for data collection, development, storage and distribution;
- Promote the free exchange of information and development of a systems view of the

Columbia River Basin;
- Provide security for data, systems and participants where necessary;
- Overcome existing information management system deficiencies;
- Ensure that information system development supports integration: laterally, with other institutions and individuals sharing a need for the information; and vertically, to roll data to different levels of resolution and scale;
- Provide for real time input of data from remote *in situ* data collection devices;
- Design, develop, test, implement and operate a coordinated, distributed, scalable information system; and,
- Obtain and maintain commitments, and develop a working process for, cooperation and standards.

3.6 Regional Coordination

A Regional RME Coordination technical/policy group is planned to provide regional coordination and points of interface between the BiOp required RME program and 1) the Federal Caucus All-H Salmon Recovery Strategy (including NMFS and USFWS TRT recovery planning efforts); 2) other regional Federal RME Programs (USFS, BLM, EPA); 3) regional state RME programs; and 4) NWPPC Fish and Wildlife Program RME (CBFWA, state/tribal fish agencies, Subbasin Planning). This group is planned to form through a regional workgroup session in September, 2002. Further steps and plans for coordination will be identified through this upcoming workgroup session with key RME participants in the region.

4.0 PILOT STUDIES

Due to the complexity of the RME program as called for in the FCRPS BIOP, the NMFS-Action Agency RME team promotes the use of pilot studies to incrementally design, field test and refine implementable components of the entire RME program. Pilot studies allow the staged development of a program that no single organization could undertake alone. As discussed above, the BIOP relies on performance measures and performance standards as assessment metrics; however, many of the metrics have not been defined. Pilot studies allow for the testing and development of the performance standard approach prior to full-scale implementation. For example, the use of physical performance standards in tributary habitat as surrogates for direct measures of survival and productivity is suggested, but no further guidance is given. Therefore, undertaking small scale monitoring efforts of broad scope with the stated objective of capturing specific fish-habitat status associations will enable the design and implementation of the most efficient large scale RME program possible. Proposed pilot studies fall into three major categories, status monitoring, effectiveness monitoring, and data management. Ultimately, a comprehensive monitoring program would integrate all of these aspects, and to some degree, this facet will be tested by the aggregation of RME pilot studies.

4.1 Status Monitoring Pilot Studies (In Progress)

4.1.1 John Day River Basin

4.1.2 Wenatchee River Basin

4.1.3 Imnaha River Basin

4.1.4 Clearwater River Basin

4.2 Pilot Studies- Action Effectiveness Research

John Day River Basin Push-up Dam Removal

RPA 183 Effectiveness Monitoring group

4.3 Pilot Studies - Data Management Prototype Systems

Pilot data management system for pilot status monitoring project in XXX River Basin

5.0 LITERATURE CITED (Needs to be edited- I lifted this from Jordan et al- but not all cites appear in text.

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